DPS

Display Panel Standard (DPS)

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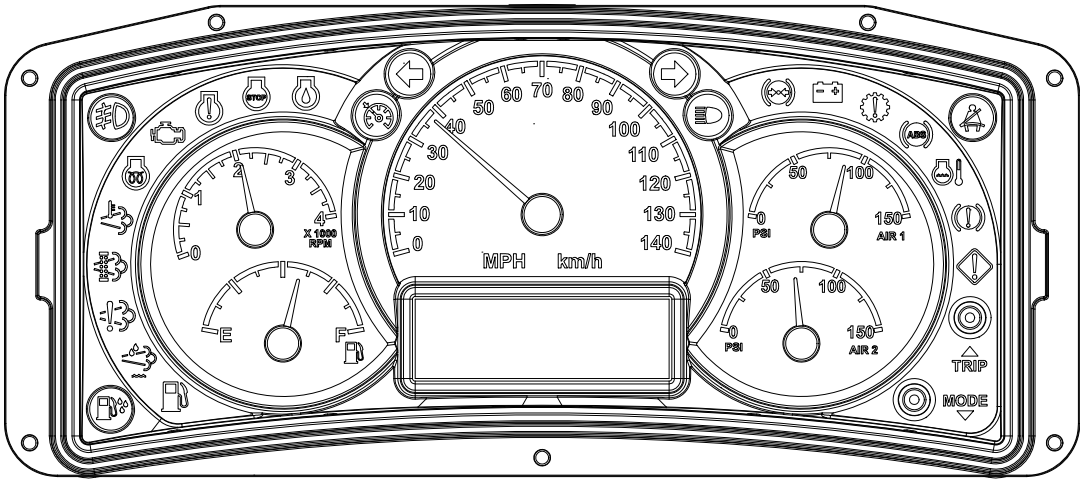

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Parker Hannifin Corporation
Electronic Controls Division
1305 Clarence Avenue
Winnipeg, MB R3T 1T4 Canada
Office +1 204 452 6776
Fax +1 204 478 1749

http://www.parker.com/ecd
http://www.vansco.ca
http://www.iqan.com

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Contents

1. Introduction **5**
1.1. Safety symbols 5
2. Precautions **6**
2.1. General safety regulations 6
2.1.1. Construction regulations 7
2.1.2. Safety during installation 7
2.1.3. Safety during start-up 7
2.1.4. Safety during maintenance and fault diagnosis 7
3. Understanding the DPS **8**
4. How to Use this Manual **10**
4.1. Diagram Conventions 10
5. Inputs **12**
5.1. DPS Digital Inputs 12
5.1.1. DPS Digital Input Capabilities 12
5.1.2. Digital Input Installation Connections 14
5.2. DPS Analog Inputs 15
5.2.1. Analog Input Capabilities 15
5.2.2. Analog Input Installation Connections 16
5.3. DPS Direct Coupled Frequency Inputs 17
5.3.1. DPS Direct Coupled Frequency Input Capabilities 18
5.3.2. Direct Coupled Frequency Input Installation Connections 18
6. DPS Outputs **20**
6.1. DPS High-Side Outputs 20
6.1.1. DPS High-Side Output Capabilities 20
6.1.2. DPS High-Side Output Installation Connections 21
6.2. DPS Low-Side Outputs with Current Sense 22
6.2.1. DPS Low-Side Outputs with Current Sense Capabilities 22
6.2.2. DPS Low-Side Outputs with Current Sense Installation Connections 24
7. Power **26**
7.1. Logic and Output Power 26
7.1.1. Logic and Output Power Installation Connections 26
7.2. Sensor Power 26
7.2.1. DPS Sensor Power Capabilities 27
7.2.2. Sensor Power Installation Connections 27
8. Communication **28**
8.1. Controller Area Network (CAN) 28
8.2. USB Communication 28

9. LCD **30**
9.1. Backlight 30
9.2. LCD Heater 30
9.3. Large Graphic LCD 31
10. Gauges **32**
10.1. Gauge Backlighting 33
11. Status LEDs **34**
12. Buttons **35**
12.1. Wake-up Feature 35
13. Buzzer **36**
14. DPS Connectors **37**
14.1. DPS Connector Pin-outs 38
15. Installing a DPS into a Vehicle **40**
15.1. DPS Mechanical Requirements 40
15.1.1. Mounting the DPS to a Vehicle 40
15.1.2. DPS Dimensions 41
15.2. DPS Environmental Requirements 42
15.3. DPS Electrical Requirements 42
16. Startup **44**
16.1. Start-up procedures 44
16.1.1. Starting the control system 44
16.1.2. Prepare for system start 45
16.1.3. Start the system 45
17. Appendix A **46**
17.1. DPS Technical Overview 46
18. Glossary of Terms **49**
19. Index **53**

1. Introduction

These instructions are meant as a reference tool for the vehicle manufacturer's design, production, and service personnel.

The user of this manual should have basic knowledge in the handling of electronic equipment.

1.1. Safety symbols

Sections regarding safety, marked with a symbol in the left margin, must be read and understood by everyone using the system, carrying out service work or making changes to hardware and software.

The different safety levels used in this manual are defined below.

WARNING

Sections marked with a warning symbol in the left margin, indicate that a hazardous situation exists. If precautions are not taken, this could result in death, serious injury or major property damage.

CAUTION

Sections marked with a caution symbol in the left margin, indicate that a potentially hazardous situation exists. If precautions are not taken, this could result in minor injury or property damage.

NOTICE

Sections marked with a notice symbol in the left margin, indicate there is important information about the product. Ignoring this could result in damage to the product.

Contact the manufacturer if there is anything you are not sure about or if you have any questions regarding the product and its handling or maintenance.

The term "manufacturer" refers to Parker Hannifin Corporation.

2. Precautions

2.1. General safety regulations

Work on the hydraulics control electronics may only be carried out by trained personnel who are well-acquainted with the control system, the machine and its safety regulations.

WARNING

Mounting, modification, repair and maintenance must be carried out in accordance with the manufacturer's regulations. The manufacturer has no responsibility for any accidents caused by incorrectly mounted or incorrectly maintained equipment. The manufacturer does not assume any responsibility for the system being incorrectly applied, or the system being programmed in a manner that jeopardizes safety.

WARNING

Damaged product may not be used. If the control system shows error functions or if electronic modules, cabling or connectors are damaged, the system shall not be used.

WARNING

Electronic control systems in an inappropriate installation and in combination with strong electromagnetic interference fields can, in extreme cases, cause an unintentional change of speed of the output function.

NOTICE

As much as possible of the welding work on the chassis should be done before the installation of the system. If welding has to be done afterwards, the electrical connections on the system must be disconnected from other equipment. The negative cable must always be disconnected from the battery before disconnecting the positive cable. The ground wire of the welder shall be positioned as close as possible to the place of the welding. The cables on the welding unit shall never be placed near the electrical wires of the control system.

2.1.1. Construction regulations

CAUTION

The vehicle must be equipped with an emergency stop which disconnects the supply voltage to the control system's electrical units. The emergency stop must be easily accessible to the operator. The machine must be built if possible, so that the supply voltage to the control system's electrical units is disconnected when the operator leaves the operator's station.

2.1.2. Safety during installation

CAUTION

Incorrectly positioned or mounted cabling can be influenced by radio signals which can interfere with the functions of the system.

2.1.3. Safety during start-up

WARNING

The machine's engine must not be started before the control system is mounted and its electrical functions have been verified.

Ensure that no one is in front, behind or nearby the machine when first starting up the machine.

Follow the instructions for function control in the Start-up section.

2.1.4. Safety during maintenance and fault diagnosis

CAUTION

Ensure that the following requirements are fulfilled before any work is carried out on the hydraulics control electronics.

- The machine cannot start moving.
- Functions are positioned safely.
- The machine is turned off.
- The hydraulic system is relieved from any pressure.
- Supply voltage to the control electronics is disconnected.

3. Understanding the DPS

The Display Panel Standard (DPS) is an innovative user interface that makes complete vehicle information accessible in a single centralized location. The Display Panel Standard is a software-programmable, multiplexing, display panel that controls indicator LEDs, gauges, and a graphic LCD screen in a vehicle HMI. The DPS also monitors various dedicated input types, and activates solid-state switched outputs.

The DPS product family is a generic platform of features that can be implemented in many different instrument cluster shapes. The figure below shows a typical DPS layout.

Figure 1: DPS with 4 gauges

The DPS is controlled by software.

- You can write the software using the Vansco Display Software Developer's Kit (SDK) tool. Contact your Parker Vansco Account Representative for more details about the SDK.

The DPS has many features, as follows:

- The DPS has 26 LEDs that are used as tell-tale lights. There are 6 green, 12 amber, 7 red and 1 blue LED. The locations of the these colors is fixed. The overlay can be configured by the customer, depending on volumes. Contact your Parker Vansco Account Representative for more details..
- The DPS is available with 3, 4, or 5 gauges and a large (256x80) LCD.
- The DPS has a buzzer that is intended to be used typically for a fault alarm, but could also be used for other noises.
- The DPS can monitor up to 27 inputs:
  - 5 analog inputs.
  - 2 frequency inputs
  - 20 digital inputs (4 are configured for Wake-up/power control).
- The DPS has up to 3 outputs, rated at 2.5 A maximum current:

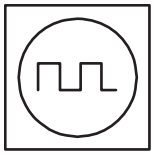
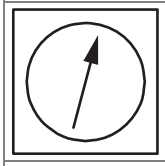
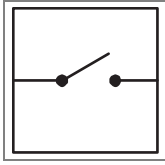
  - 1 high-side output (configured for alternator excitation and is limited to 80mA max).
  - 2 low-side outputs (these outputs monitor current, and can be used for current feedback if a high-side output is used for Pulse Width Modulation (PWM) control).
- The DPS can detect the following faults on the outputs:
  - Short-circuit
  - Over-current
  - Open load
  - Short-to-battery
  - Short-to-ground
- The DPS has 3 connectors:
  - 2 x 20-pin Molex connectors that are used to interface with the inputs, outputs, and CAN.
  - 1 x 4-pin Molex connector for USB interface, typically routed to a panel mounted USB port.
    a) A separate cable is available to provide the interface from the 4-pin molex connector to a USB, type B port.

4. How to Use this Manual

This manual describes the hardware components of the DPS, but does not explain how to write or configure the software. For more information about software, refer to the appropriate software manual, or contact your Parker Vansco Account Representative.

4.1. Diagram Conventions

There are many connection diagrams found throughout this manual. The following table provides meanings for the different symbols used in those diagrams:

Symbol	Meaning
	General input
	General output
	Frequency input
	Analog input
	Frequency sensor
	Pulse sensor
	Resistive sensor
	General sensor
	Application switch

Symbol	Meaning
	Load
	Pull-down resistor
	Pull-up resistor
	Battery
	Fuse
	Resistor
	Ground
	Chassis ground

5. Inputs

The DPS has three types of inputs, as follows:

- Digital
- Analog
- Frequency

NOTICE

Do not connect inputs directly to unprotected inductive loads such as solenoids or relay coils, because they can produce high voltage spikes that may damage the DPS. If an inductive load must be connected to an input, use a protective diode or transorb.

5.1. DPS Digital Inputs

The DPS has 20 digital inputs:

- `INPUT1_D` through `INPUT20_D`.

The digital inputs can be categorized into two groups called type 1 and type 2. Four of the digital inputs (`INPUT1_D` through `INPUT4_D`) are type 1, and the remaining digital inputs (`INPUT5_D` through `INPUT20_D`) are type 2.

The differences between the two types of digital inputs are the switching thresholds and the maximum processing speeds.

5.1.1. DPS Digital Input Capabilities

5.1.1.1. Type 1

Type 1 digital inputs are processed quicker than type 2 digital inputs. All type 1 digital inputs have an option to be populated as either an active high input (with a pull-down resistor), or an active low input (with a pull-up resistor). The pull-up resistors are referenced to a switched battery supply, which is equivalent to the battery voltage when the unit is in normal operating power mode, but is disconnected when in inactive or disconnected power modes.

The type 1 digital inputs can be configured as wake-up inputs. When a high signal is applied to a digital input configured as a wake-up input when the unit is in inactive power mode, the unit will enter normal operating mode and begin to operate. A digital input that is configured as a wake-up input must also be configured as an active high input (pull-down resistor) to prevent the system from continuously remaining powered up. All configuration is done using the Parker Vansco Display SDK.

INPUT1_D through INPUT4_D are type 1 inputs. On the standard DPS configuration, type 1 inputs have 2.0K ohm pull-down resistors and are configured as wake-up inputs.

The following table provides specifications for the DPS's type 1 digital inputs:

Table 1: Type 1 Digital Input Capabilities

Item	Min	Nom	Max	Unit
Input voltage range	0	-	32	V
Pull-up / pull-down resistance	-	2		kΩ
Minimum negative going threshold	-	-	1.587	V
Maximum positive going threshold	4.013	-	-	V
Error in switching threshold due to circuit leakage current			13	mV
Cutoff frequency (3dB)	-	242	-	Hz
Input capacitance	-	50	-	nF
Over-voltage	-	-	36	V
Wetting current	-	12	-	mA
Amplifier gain	-	2	-	V/V

5.1.1.2. Type 2

All type 2 digital inputs have an option to be populated as either an active high input (with a pull-down resistor), or an active low input (with a pull-up resistor). The pull-up resistors are referenced to a switched battery supply, which is equivalent to the battery voltage when the unit is in normal operating power mode, but is disconnected when in inactive or disconnected power modes.

Some of the type 2 digital inputs can be configured as wake-up inputs. When a high signal is applied to a digital input configured as a wake-up input when the unit is in inactive power mode, the unit will enter normal operating mode and begin to operate. A digital input that is configured as a wake-up input must also be configured as an active high input (pull-down resistor) to prevent the system from continuously remaining powered up.

INPUT5_D through INPUT20_D are type 2 inputs. On the standard DPS configuration, type 2 inputs 9-12, 14, and 19 have 2.0K ohm pull down resistors. Type 2 inputs 5-8, 13, 15-18, and 20 have 2.0K ohm pull up resistors.

The following table provides specifications for the DPS's type 2 digital inputs:

Table 2: Type 2 Digital Input Capabilities

Item	Min	Nom	Max	Unit
Input voltage range	0	-	32	V
Pull-up / pull-down resistance	-	2		kΩ
Minimum negative going threshold	-	-	1.953	V
Maximum positive going threshold	4.668	-	-	V
Error in switching threshold due to circuit leakage current			47.5	mV
Cutoff frequency (3dB)	-	670	-	Hz

Item	Min	Nom	Max	Unit
Input capacitance	-	50	-	nF
Over-voltage	-	-	36	V
Wetting current	-	12	-	mA
Amplifier gain	-	2	-	V/V

5.1.2. Digital Input Installation Connections

You must be aware of the following when connecting digital inputs:

A digital input is typically connected to a switch that is either open or closed.

- **When the switch is open**, the pull-down resistor will ensure no voltage exists on the input signal, which will be interpreted by the DPS as inactive.
- **When the switch is closed**, the input is connected to battery voltage, which will be interpreted by the DPS as active.

Since the input is active high

- It must be connected to battery power to ensure there is a battery connection when the state of the input changes.
- The power provided to the digital switch connected to the input must be provided through a fuse in the wire harness.

The following shows a typical active high digital input connection:

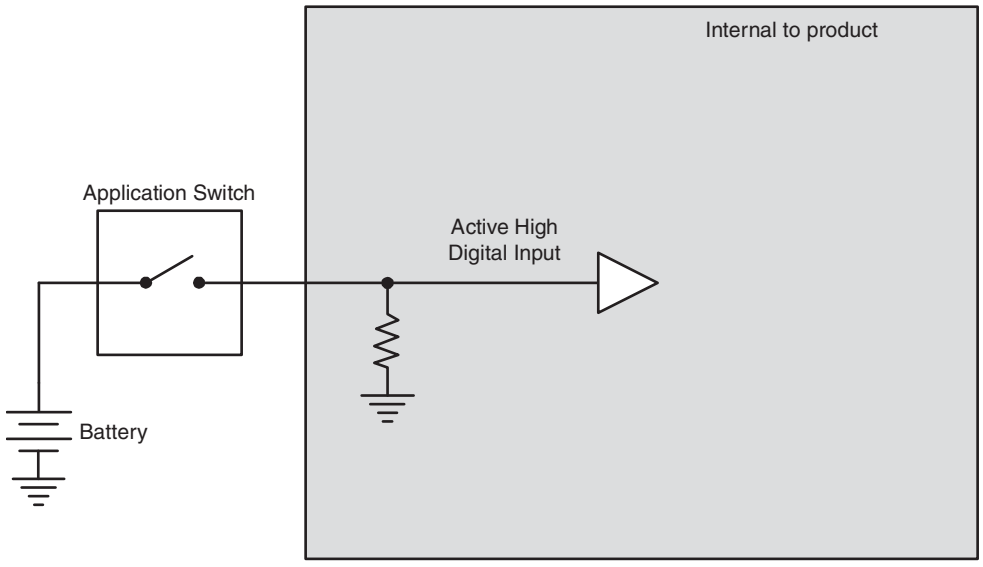


Figure 2: Active high digital input

5.2. DPS Analog Inputs

Analog inputs are typically used to read electrical signals that span a voltage range.

The DPS has 5 analog inputs:

- INPUT21_A through INPUT24_A (Analog 1 through Analog 4).
- A high-side output, OUTPUT2_HS has been configured as a 5th analog input in the standard DPS variants (Analog 5).

Three of the analog inputs, INPUT21_A, INPUT22_A and INPUT24_A are type 1, and INPUT23_A is type 3.

INFORMATION

Analog inputs can be configured to function as programmable digital inputs.

5.2.1. Analog Input Capabilities

5.2.1.1. Type 1

Type 1 analog inputs have an option for a pull-up resistor referenced to a regulated +5V supply (through a diode, so actual reference will be about 4.4V), and options for pull-down resistors to provide a wider array of input range options. Type 1 analog inputs are well-suited to read resistive sensors or voltage sensors.

The standard DPS variants type 1 analog inputs are configured as follows:

- Analog 1 is configured for resistive loads and has an input range of 0-350Ω with a 150Ω pull-up.
- Analog 2 is configured for voltage loads and has an input range of 0-16V.
- Analog 4 is configured for voltage loads and has an input range of 0-6.6V.

5.2.1.2. Type 2

Type 2 analog inputs are well-suited to read voltage sensors, but are not recommended for resistive sensors, because they do not have a regulated pull-up reference (as the type 1 and type 3 inputs have).

The standard DPS variant high side output OUTPUT2_HS is configured to be used as an additional analog input. It is a type 2 analog input and is configured as follows:

- Analog 5 is configured for voltage loads and has an input range of 0-6.6V.

5.2.1.3. Type 3

The type 3 input is essentially the same as the type 1 inputs with the exception that it has a software selectable pull-up resistor. This software selectable pull-up resistors is intended to allow for an extended range when the input is configured for reading a resistive sensor. An extended range is often required for reading thermistors that operate over a large temperature range.

The standard DPS variants type 3 analog inputs are configured as follows:

- Analog 3 is configured for resistive loads and has a input range of 600-100KΩ.

5.2.2. Analog Input Installation Connections

When connecting analog inputs, there are two issues you must be aware of: system noise and ground shift.

System Noise

Analog inputs are more susceptible to system noise than digital inputs. Too much system noise can create inaccurate analog input readings.

To reduce system noise:

- Use the shortest possible wires when connecting analog inputs to sensors, to prevent noise pickup on the sensors.

The following shows how to connect analog inputs to reduce system noise:

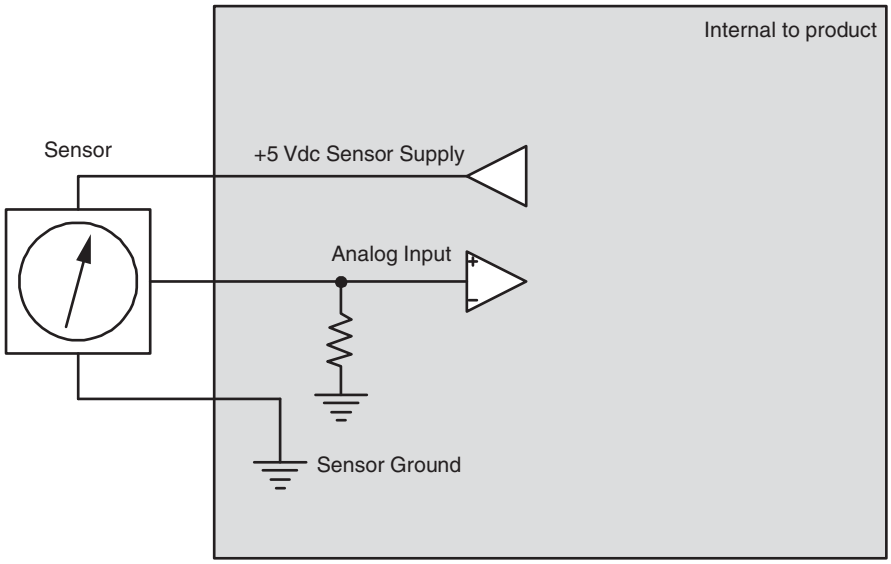


Figure 3: Analog input system noise connection

Ground Shift

The accuracy of analog inputs can be affected by ground shift. Ground shift refers to the difference between the DPS system ground input voltage (system ground inputs are called GND), and the sensor ground voltage.

To reduce ground shift:

- Dedicate one of the four system ground inputs (GND) to sensors that have dedicated ground wires, and connect all sensor grounds to this system ground input.
- Splice the other three system ground inputs together in the vehicle harness (close to the connector), to provide a better ground for the noisier low-side outputs and digital circuits.

- Ensure the sensor's ground connection is close to the system ground connections. This will help ensure the signal remains within the digital activation range of the input.

INFORMATION

The DPS system ground inputs are rated for low-current signals, which ensures the sensor's ground is very close in voltage potential to the system ground.

INFORMATION

Sensors that don't have a dedicated ground wire are typically grounded to the vehicle chassis through the sensor's body.

The following shows how to address ground shift with sensors that have dedicated ground wires:

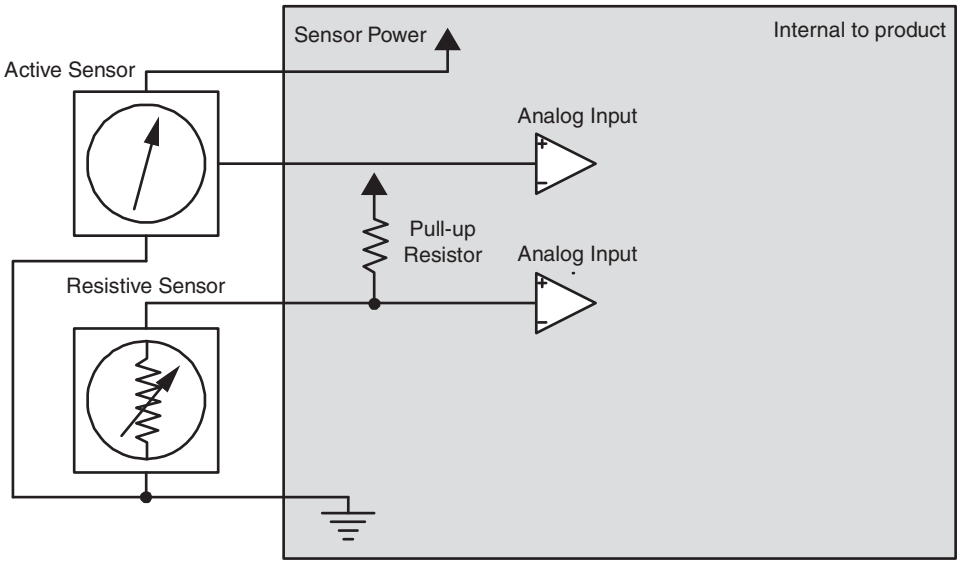


Figure 4: Analog input ground shift connection for sensors that have dedicated ground wires

5.3. DPS Direct Coupled Frequency Inputs

There is one type of frequency input in the DPS:

- Direct coupled frequency input

Direct coupled frequency inputs are typically used to read pulse signals.

The DPS has 2 direct coupled frequency inputs:

- `INPUT25_F` to `INPUT26_F`

5.3.1. DPS Direct Coupled Frequency Input Capabilities

Direct coupled frequency inputs allow you to read the frequency of external signals that have a ground reference and no DC offset. These inputs are ideal for use with hall-effect type sensors.

INFORMATION

Quadrature and pulse counting is possible with direct coupled frequency inputs.

The following table provides specifications for the DPS's direct coupled frequency inputs:

Table 3: Direct Coupled Frequency Input Capabilities

Item	MIN	NOM	MAX	UNIT
Negative going switching threshold			.904	V
Positive going switching threshold	1.11			V
Input capacitance at pin		500		pF
Gain (Vcomp/Vpin)		1		V/V
Cut-off frequency (3dB)		6.4		kHz
Pull-up resistor		10		kΩ
Pull-up reference voltage		4.4		V

5.3.2. Direct Coupled Frequency Input Installation Connections

When connecting direct coupled frequency inputs, there are two issues you must be aware of: system noise and ground shift.

System Noise

Direct coupled frequency inputs are more susceptible to system noise than digital inputs.

To reduce system noise:

- Connect direct coupled frequency inputs to sensors that produce signals with no DC offset.
- Use the shortest possible wires when connecting direct coupled frequency inputs to sensors to prevent noise pickup on the sensors.

Ground Shift

Ground shift affects the accuracy of direct coupled frequency inputs. Ground shift refers to the difference between the system ground input (GND) voltage, and the sensor ground voltage.

To reduce ground shift:

- Dedicate one of the 2 system ground inputs (called GND) to sensors that have dedicated ground wires, and connect all sensor grounds to this system ground input.

- Splice the other system ground inputs together in the vehicle harness (close to the connector), to provide a better ground for the noisier low-side outputs and digital circuits.
- Ensure the sensor's ground connection is close to the system ground connections. This will help ensure the signal remains within the digital activation range of the input.

INFORMATION

The DPS system ground inputs are rated for low-current signals, which ensures the sensor's ground is very close in voltage potential to the system ground.

INFORMATION

Sensors that don't have a dedicated ground wire are typically grounded to the vehicle chassis through the sensor's body.

The following shows a typical direct coupled frequency input connection:

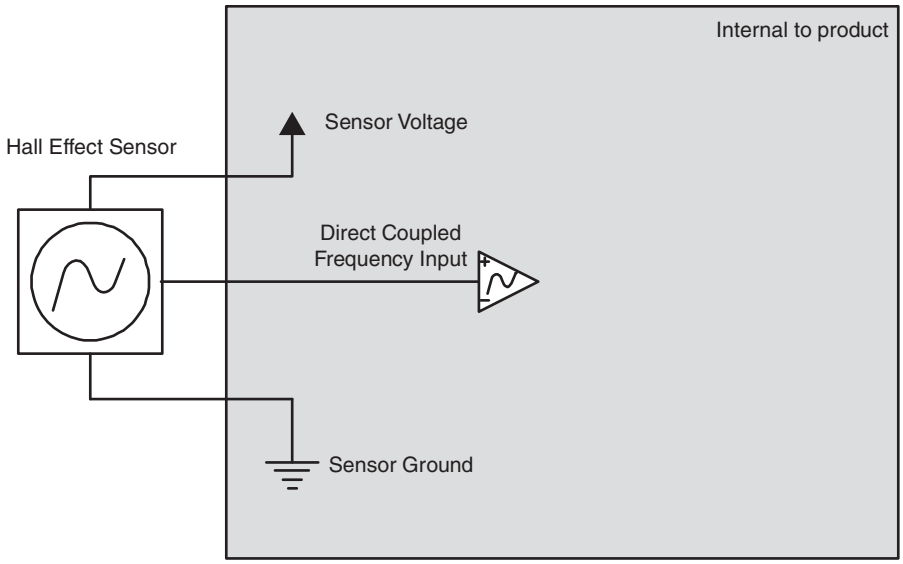


Figure 5: Direct coupled frequency input installation connections

6. DPS Outputs

The DPS has solid-state FET technology outputs designed for low to medium current and high inrush inductive load switching. Output currents can range up to 2.5 A.

The DPS has 2 types of outputs:

- High-side outputs
- Low-side outputs with current sense

6.1. DPS High-Side Outputs

The DPS has 1 high-side output:

- `OUTPUT1_HS` (configured for 80 mA alternator excitation).

6.1.1. DPS High-Side Output Capabilities

High-side outputs are used for switching voltages to loads using either a **pulse width modulated (PWM) signal**, or an **on/off signal**. They can also test for various fault conditions, which can be used for software diagnostics (refer to *High-Side Output Diagnostics and Fault Protection* for more details).

All high-side outputs come with internal flyback diodes that provide protection when driving inductive loads.

- **When a high-side output is used as a PWM signal**, a pulsed output signal is provided by the DPS, where the percentage of time that the output is “on” vs. “off” is determined by the duty cycle of the signal, and the duty cycle is determined by the application software.
- **When a high-side output is used as an on/off signal**, the output provides battery voltage when in the “on” state (the application software is responsible for switching high-side outputs "on" and "off").

The following table provides specifications for the DPS high-side outputs:

Table 4: High-Side Output Specifications

Item	Min	Nom	Max	Unit
Operational voltage range	7	-	32	V
Over-voltage	-	-	36	V
Output current range	0	-	2	A
Load impedance @ 12 V	4	-	-	Ω
PWM frequency	5	-	500	Hz
PWM *resolution*[1]	-	0.1	-	%

[1] This is the typical value. Actual value is dependent on the base frequency, since the counter used for this operation has a finite number of steps.

Item	Min	Nom	Max	Unit
Flyback diode *current*[2]	-	-	1	A
Short-circuit current limit (Tjunc = -40ºC to +150ºC)	9	15	23	A
Short-circuit trip time	-	2	-	ms
Thermal protection	-	150	-	ºC
Digital feedback negative threshold	1.5	-	-	V
Digital feedback positive threshold	-	-	3.58	V
Digital feedback cutoff frequency	-	322	-	Hz
Open-load detection – max detectable load @ 12 V	-	-	1.4	kΩ
Open-load detection pull-up	9.8 k	-	10.2	kΩ
Current sensing	-	No	-	-
Analog feedback	-	No	-	-

6.1.1.1. High-Side Output Diagnostics and Fault Protection

Each high-side output has the ability to report many different fault conditions.

The types of faults that are reported are determined by the configuration of your high-side outputs, and this configuration must be considered when writing the application software.

6.1.2. DPS High-Side Output Installation Connections

You must be aware of the following when connecting the high-side output:

- The high-side output is connected to an internal bus bar, which can be connected to a **+12 V** or **+24 V** battery. The bus bar is connected to logic power (`VBATT`), and both share the same connector pins.
- The high-side output can provide switched battery power to any load type in a vehicle.
- The high-side output can source up to **80mA** in the alternator excitation configuration.
- The high-side output has an internal flyback diode, which is needed when driving an inductive load (the flyback diode absorbs electrical energy when the load is turned off).

INFORMATION

Inductive loads will create an average current flow that moves out of the high-side output. When the output is on, the current flows through the output driver, and when the output is off, the current flows through the flyback diode. A duty cycle of 50% will produce the worst case average current flow through these two devices.

[2] This is an average current value, meaning a worst case PWM current of 2 A at 50% duty cycle is possible with inductive loads.

NOTICE

If large inductive loads are used, and the high-side output is providing a continuous PWM signal, then the PWM peak current must not be greater than the specified continuous current for the output (in continuous mode, the average current flow through the diode at 50% duty cycle is approximately equal to ½ the peak current).

When connecting high-side outputs, ensure you follow these best practices:

- High-side outputs should not be connected to loads that will draw currents greater than the maximum peak current, or maximum continuous current.
- The grounds for the loads should be connected physically close to the DPS power grounds.

The following shows a typical high-side output connection:

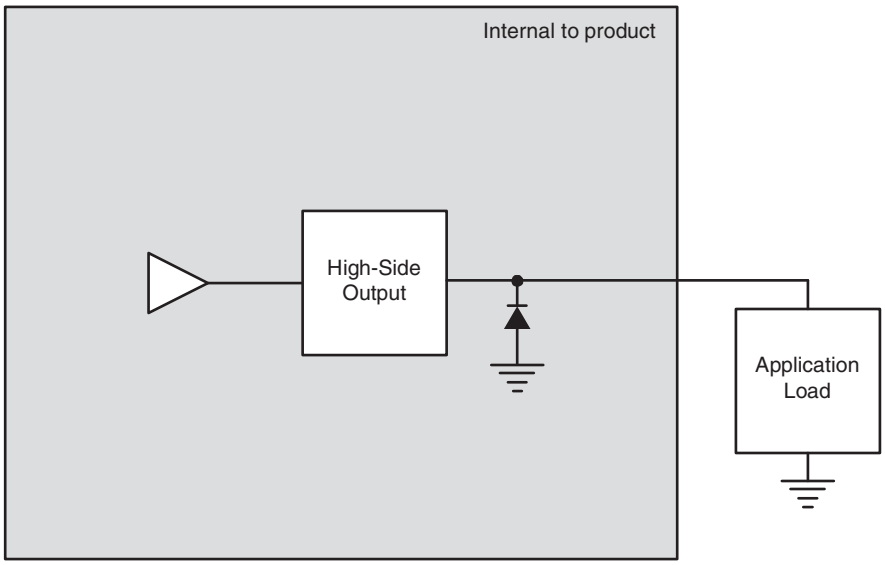


Figure 6: Typical high-side output installation connections

6.2. DPS Low-Side Outputs with Current Sense

The DPS has 2 low-side outputs:

- `OUTPUT3_2A5_LS` to `OUTPUT4_0A7_LS`

6.2.1. DPS Low-Side Outputs with Current Sense Capabilities

Low-side outputs with current sense are used for switching grounds to loads using either a **pulse width modulated (PWM) signal**, or an **on/off signal**. They also have the ability to **sense current** that is provided to loads, through an amplifier circuit.

- **When a low-side output is used as a PWM signal**, a pulsed output signal is provided by the DPS, where the percentage of time that the output is “on” vs. “off” is determined by the duty cycle of the signal, and the duty cycle is determined by the application software.

INFORMATION

Current flow gets interrupted when using low-side outputs as a PWM signal, because the outputs are not "on" continuously. Therefore, the DPS can not support current feedback control systems if the output is being PWMed.

- **When low-side outputs are used as an on/off signal**, the output provides ground when in the “on” state (the application software is responsible for switching low-side outputs "on" and "off").
- **When low-side outputs are used to sense current**, the application software will monitor the current flowing into the low-side output, and based on the amount of current, will turn the output either "on" or "off".
    - The amplifier that measures the sensed current has an allowable voltage range of 0 V to 3 V. The application software will protect the circuit from an over-current or short-circuit event when the voltage from the amplifier reaches 2.9 V; therefore, the actual usable voltage range from the amplifier is only 0 V to 2.8 V.

The following table provides specifications for the DPS 2.5A low-side output:

Table 5: 2.5A Low-Side Output with Current Sense Configuration

Item	Min	Nom	Max	Unit
Output voltage range	0	-	0.25	V
Output current	-	-	2.5	A
On resistance	-	45	100	mΩ
Maximum voltage applied to output pin	-	-	32	V
Current limit in short-to-battery condition	18	24	30	A
Maximum PWM frequency	-	500	-	Hz
PWM resolution	-	No	200	µs
Flyback diode continuous current			1	A
Flyback diode non-repetitive surge current	-	-	30	A
Output pull-down resistance	-	8.39	-	kΩ
Output pull-up resistance	-	10	-	kΩ
Feedback gain (Vmicro/Vpin)	-	1/11	-	V/V
Feedback max readable voltage	-	-	36.3	V
Feedback cut-off (3dB) frequency	-	322		Hz
Feedback worst case fixed error	-	-	±251	mV
Feedback worst case relative error	-	-	±2.8	%

The following table provides specifications for the DPS 0.7A low-side output:

Table 6: 0.7A Low-Side Output with Current Sense Configuration

Item	Min	Nom	Max	Unit
Output voltage range	0	-	0.945	V
Output current	-	-	0.7	A
On resistance	-	550	1350	mΩ

Item	Min	Nom	Max	Unit
Maximum voltage applied to output pin	-	-	32	V
Current limit in short-to-battery condition	1	1.5	1.9	A
Communication frequency	-	10.4	12.5	kHz
Output pull-down resistance	-	52.5	-	kΩ
Output pull-up *resistance*[3]	-	1	-	kΩ
Feedback cut-off frequency	-	31.8		kHz
Feedback low *threshold*[4]	0.4*VSW	-	0.53*VSW	V
Feedback high threshold	0.47*VSW	-	0.6*VSW	V
Feedback hysteresis	0	-	0.2*VSW	V

Table 7: Low-side output PWM control methods

High-side output	Preferred PWM control method	Secondary PWM control method
OUTPUT3_2A5_LS	Software PWM control	
OUTPUT4_0A7_LS	Software PWM control	

6.2.2. DPS Low-Side Outputs with Current Sense Installation Connections

You must be aware of the following when connecting low-side outputs:

- Low-side outputs are connected to a common internal ground point that is connected to the battery ground (GND). Refer to *Logic and Output Power* for more details about the battery ground.
- Low-side outputs provide switched ground to any load type in a vehicle.
- Low-side outputs can sink up to **2.5 A**.
- When connecting a load to a low-side output, **ensure the load will not** drive currents greater than the maximum specified peak current, or maximum specified continuous current.

[3] Pull-up resistance is referenced to VSW (switched battery voltage).
[4] The switching thresholds are relative to VSW (switched battery voltage).

The following shows a typical low-side output connection:

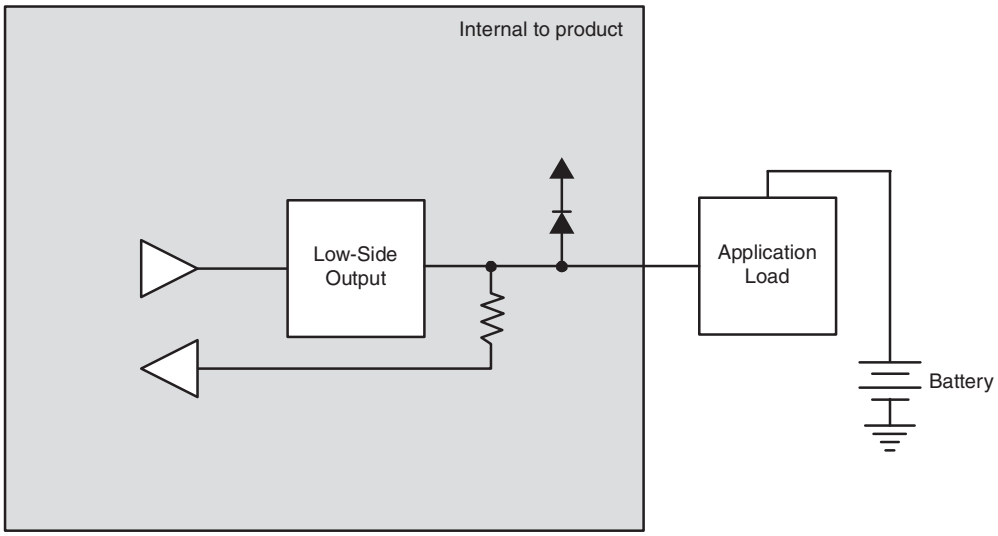


Figure 7: Low-side outputs with current sense installation connections

7. Power

The DPS is powered by the vehicle battery. The DPS operates in a system, and can operate from up to , with overvoltage protection at protection.

The DPS has various pins on the connectors that are used for different types of power, as detailed in the following sections.

7.1. Logic and Output Power

The DPS has **1 pin(s)** dedicated to providing power for logic and outputs, called `VBATT`, and **2 pin(s)** dedicated to grounding the DPS, called `GND`.

INFORMATION

The power and ground connections are usually paralleled over several pins to minimize voltage drops on higher current applications.

7.1.1. Logic and Output Power Installation Connections

When connecting the DPS logic and output power, you should be aware of the following:

- Logic and output power connections are made using the `VBATT` and `GND` pins.
- The number of wires needed to connect the DPS power depends on the amount of current required by the application. It is recommended to use **one (1) 16 AWG wire** for every **8 A** of expected output current; however, this is not always true and ultimately depends on your application.
- The DPS is protected against reverse battery connections by an internal high-current conduction path that goes from ground to power. To protect the DPS from damage in a reverse battery condition, place a fuse of **20 A or less** in series with the power wires in the application harness.
- All power connections to the DPS should be fused to protect the vehicle harness.

INFORMATION

The system designer is responsible for selecting the appropriate fuses. Select fuse sizes by multiplying the maximum continuous current during normal operation by 1.333 (75% de-rating factor). Do not use slow blow fuses for this application.

7.2. Sensor Power

The DPS has one pin dedicated to providing power to external sensors called `SENSOR_SUPPLY`.

WARNING

Do not drive more than **50 mA** of current through the SENSOR_SUPPLY pin. If you do, the pin will protect itself by dropping the voltage, which will result in a lack of power to your sensors, potentially causing unknown vehicle responses.

7.2.1. DPS Sensor Power Capabilities

SENSOR_SUPPLY is a 5 V linear power supply that is capable of continuously providing **<Sensor_Supply_n1> mA** to external sensors.

INFORMATION

The voltage provided to the DPS must be 6.5 V or greater to ensure the sensor supply can provide 5 V.

The following table provides specifications for the DPS sensor power:

Table 8: Sensor Power Specifications

Item	Min	Nom	Max	Unit
Output voltage range	4.8755	5.0	5.1255	V
Operational current output	-	-	50	mA
Short circuit voltage	0	-	32	V
Analog feedback voltage range	0	-	6.6	V
Analog feedback gain (Vmeasured/5V reference)	-	0.5	-	V/V
Analog feedback cut-off frequency	-	265	-	kHz
Analog feedback relative error	-	-	±2.0	%
Analog feedback fixed error	-	-	±50	mV

7.2.2. Sensor Power Installation Connections

For information on how to connect sensors, refer to Application Examples.

8. Communication

The DPS uses two methods of communication when communicating with other modules on the vehicle, or with a personal computer:

- CAN communication
- USB communication

8.1. Controller Area Network (CAN)

The DPS hardware provides CAN communication according to the **SAE J1939 specification**, making the DPS compatible with any CAN-based protocol through software.

CAN communication is used to communicate the status of multiple modules that are connected together in the same network.

The standard DPS has 2 CAN ports. Each CAN interface has a software selectable 120Ω terminating resistor.

8.2. USB Communication

The DPS can send and receive data with a personal computer, using an USB communication channel. The USB connection is intended for service use only (for example, downloading data logs, updating application code, configuring the unit with a service tool, etc.), it is not intended to be connected at all times in the application.

There are 4 pins used for USB communication:

- Vbus
- D-
- D+
- GND

The USB circuitry is electrically isolated from the rest of the circuitry on the DPS using optical isolators. The reason for the isolation is to protect the DPS or PC from being damaged in the case that the DPS and the USB host (PC) have different ground potentials.

The following table specifies the parameters for the USB interface:

Table 9: USB interface parameters

ITEM	MIN	NOM	MAX	UNITS
Absolute maximum voltage applied to USB Power	-0.5		6.0	Volts

USB Power Operating Voltage	3.3	5.0	5.25	Volts
Operating Supply Current		15		mA
Absolute maximum voltage applied to data signals	-0.5		3.8	Volts
Data Signal Operating Output Voltage (High)	2.8		3.6	Volts

9. LCD

The LCD that is supported in the DPS is:

- A large graphic LCD (256 x 80 pixel)

9.1. Backlight

The LCD is backlit with LED backlighting. The LEDs used for the LCD backlighting populated is tri-colour LEDs

The tri-colour backlighting LEDs allows the option of having the LCD change colours through software control. This may be required by certain customers to signal an error condition being displayed on the LCD, or it may be required to give users different options in the LCD backlighting colour.

The brightness control of the LCD is driven with a PWM signal, which means that variable brightness of the backlighting is possible. The tri-colour LED controls do not have PWM control, and are only on/off control signals. This means that the number of different colours possible for the LCD backlighting is limited to 7 when using tri-colour LEDs. The 7 possible colours that can be achieved with the tri-colour LEDs are:

- Red
- Green
- Blue
- Light Blue
- Purple
- Yellow
- White

The LED colours and brightness are configured by the user through the software tool.

9.2. LCD Heater

There is an LCD heater populated on the DPS. The LCD heater is required for the graphic LCDs to operate in an ambient temperature below -20°C. With the use of the LCD heater the graphic LCD can operate down to -40°C. The LCD may take a few minutes to heat up to the point where it is visible at -40°C. When the LCD first starts up at -40°C, it will take the heater approximately 5 minutes to heat up the LCD to the point where the LCD is legible, about 10 minutes before the LCD is very clearly legible, and about 20 minutes before the response time of the LCD is less than 2 seconds.

The DPS cluster has an internal temperature sensor that is used to determine the ambient temperature so the LCD heater will only be turned on in cold conditions, and not when the ambient temperature is above freezing temperatures.

9.3. Large Graphic LCD

The large graphic LCD is the standard LCD for the DPS. The LCD is a monochrome FSTN (film super twisted nematic) transflective, positive image LCD, with a resolution of 256 x 80 pixels. It has been designed for use in both low and high ambient light conditions. The best viewable contrast is when viewed from above the horizontal plane of the LCD.

The LCD has an operating temperature of -20°C to +70°C. However, with the use of the heater the lower operating temperature can be extended to -40°C. The LCD will operate up to an ambient temperature of +85°C, however the contrast and viewing angle will degrade above +70 °C. This means that the LCD will not look as nice at +85°C, but it will still be legible.

10. Gauges

The DPS has a 3, 4 or 5 gauge configuration.

The following diagrams shows the gauge positions.

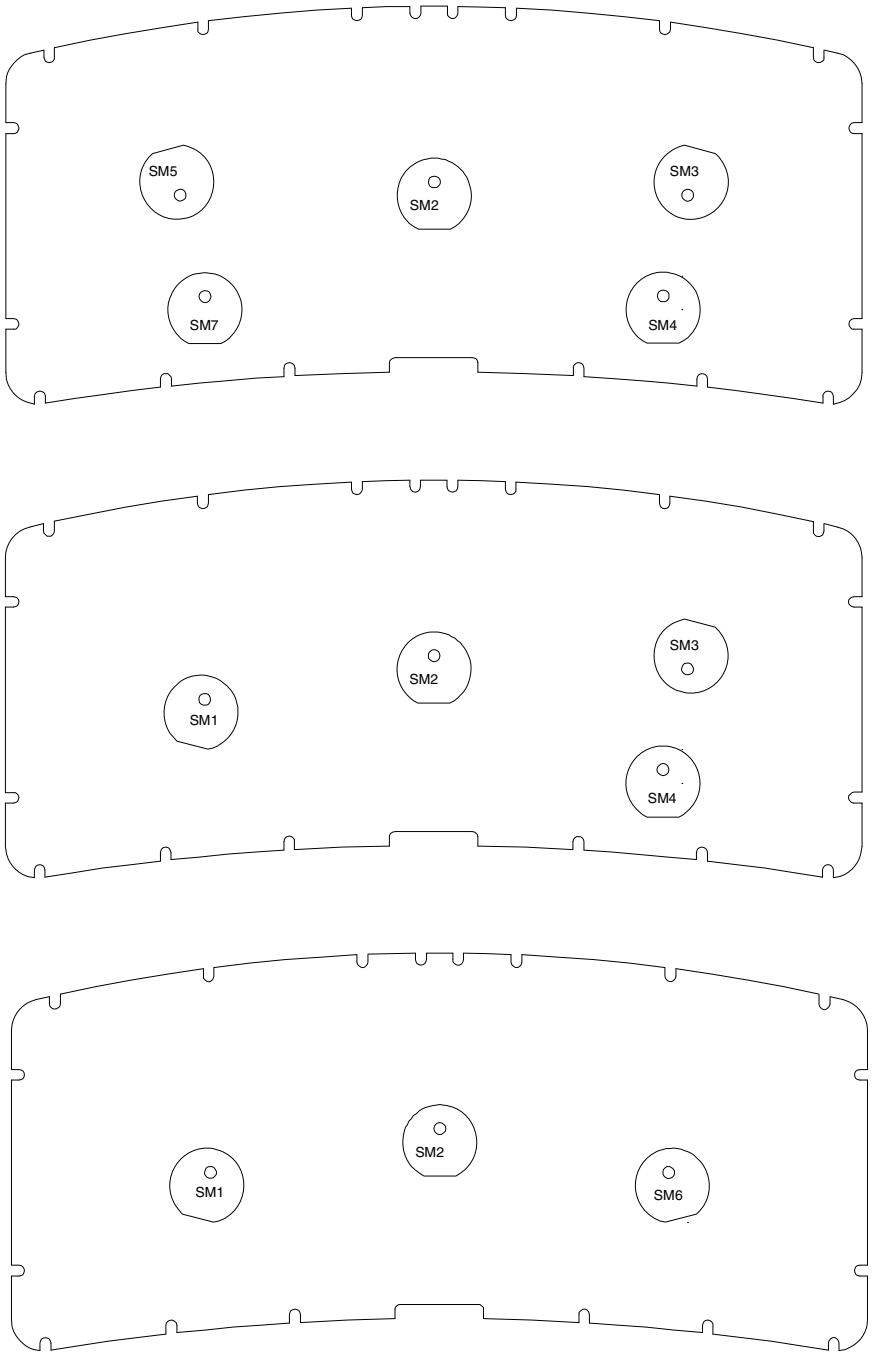


Figure 8: DPS gauge locations

The DPS gauges are controlled by microstepping, except for the gauge on the bottom left side of the display, labeled SM7. Microstepping allows for finer resolution, when compared to partial stepping of the gauge, which is how SM7 is driven. This means that SM7 will look a little more coarse for small movements than the other gauges. This will not be noticeable for gauges that are representing vehicle parameters that do not change quickly, such as the fuel gauge, or temperature gauges. However, the SM7 location may not be suitable for gauges that represent faster moving vehicle parameters, such as RPM or speed. This should be considered when determining the function of SM7 in your application.

10.1. Gauge Backlighting

The DPS gauges are backlit with LED backlighting. The LEDs used for the gauge backlighting are tri-color LEDs. The tri-color backlighting LEDs allows for the option of the gauges to change colors through software control.

The brightness control of the gauges are driven with a PWM signal, which means that variable brightness of the backlighting is possible using the DPS configuration software. The tri-color LED controls are also driven by PWM control, which means that many different shades of color are possible for the gauge backlighting. If the gauge backlighting control signals are only used as on/off in software, then the are are 7 colors that are possible. The 7 possible colors that can be achieved with the tri-color LEDs in on/off control are:

- Red
- Green
- Blue
- Light Blue
- Purple
- Yellow
- White

There are also red LEDs that are used to light up the gauge pointers. The pointer backlighting cannot be dimmed, it is only on or off.

11. Status LEDs

There are 26 status LEDs on the DPS cluster. These are positioned as shown in the following figure.

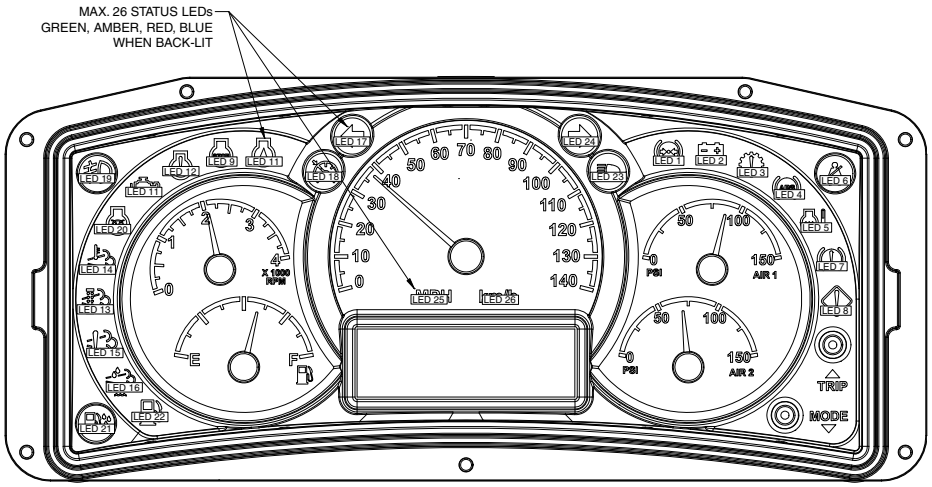


Figure 9: DPS status LEDs

Each of the status LEDs is a single color LED, and is one of the following colors:

- Green (LED 17, 18, 19, 24, 25, 26)
- Amber (LED 3, 4, 8, 11, 12, 13, 14, 15, 16, 20, 21, 22)
- Red (LED 1, 2, 5, 6, 7, 9, 10)
- Blue (LED 23)

The icons associated with each status LED is determined by the overlay, which can be customer specific.

12. Buttons

There are two buttons on the DPS that are used for the user to interface to the unit. These buttons use rubber button caps over metal switch domes that, when pushed, close the switches electrically.

The switch domes have a trip force of 700 grams +/- 40 grams. The rated life of the dome is 1,000,000 cycles.

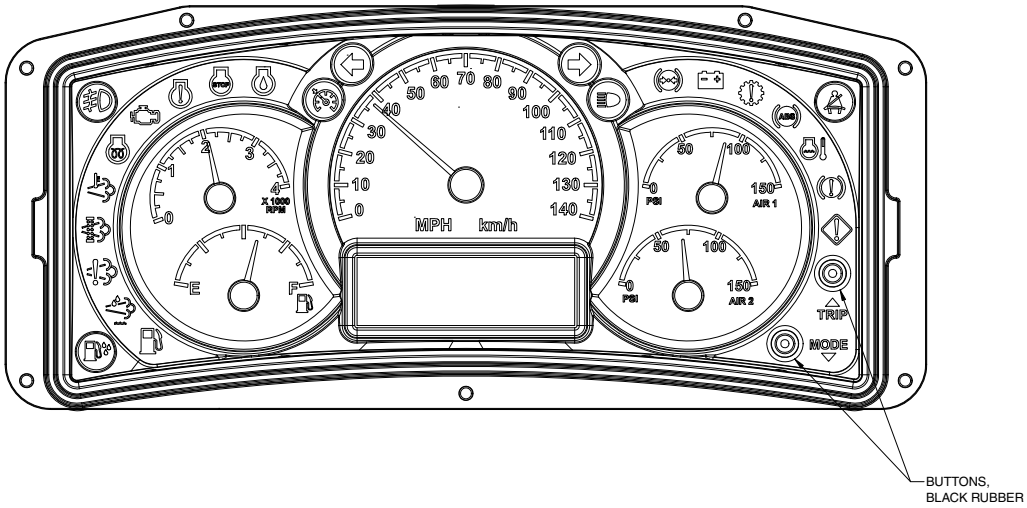


Figure 10: DPS button locations

12.1. Wake-up Feature

The buttons can be configured to wake-up the DPS when they are pressed. The wake-up feature allows information to be displayed on the LCD when the button is pressed, even if the ignition is inactive. The wake-up feature is application controlled.

13. Buzzer

The DPS has a buzzer that is intended to be used for a fault alarm, but it has also been used for other noises (e.g. to create a relay clicking noise) in some applications.

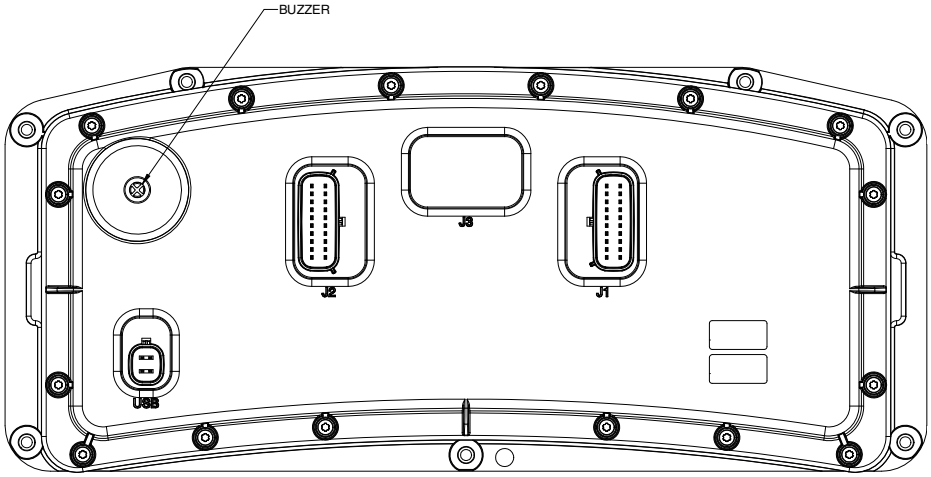


Figure 11: DPS buzzer location

There is a hole in the back cover of the enclosure to allow the sound to exit the DPS. A buzzer gasket is placed between the buzzer housing and the back cover, which prevents water and dust from entering the unit. This gasket also acts as a tunnel for the sound coming from the buzzer. The buzzer is significantly louder with the gasket installed.

14. DPS Connectors

There are up to four Molex MX-150 style connectors shells molded into the rear cover. Connectors J1, J2, and J4 (USB) are used to interface with external signals.

Connectors J1 and J2 have 20 positions.

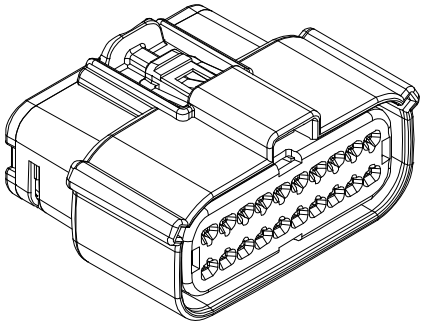


Figure 12: 20 position MX-150 connector

Connector J4 (USB) has 4 positions.

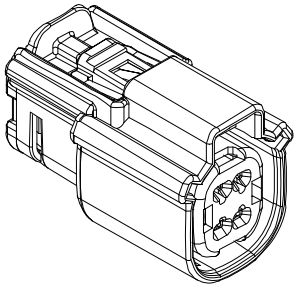


Figure 13: 4 position MX-150 connector

The following table shows the part numbers for the mating connectors that are used in the vehicle harness:

Table 10: Mating Connector Part Numbers

Connector	Molex part no. with Connector Position Assurance	Molex part no. without CPA
Grey (J1) connector 20 position, key option B	334722007	334722002
Black (J2) connector 20 position, key option A	334722006	334722001
Black (J4) USB connector 4 position, key option A	334720406	334720401

14.1. DPS Connector Pin-outs

Connector pins connect to inputs, outputs, and communication channels. They provide the interface between the vehicle harness and the internal circuitry of the DPS.

The following tables show the pin-outs for each connector:

Table 11: Grey (J1) Connector Pin-out

Connector pin	Name	Function
1	INPUT2_D	Digital input
2	INPUT1_D	Digital input
3	CAN2_SHLD	CAN 2 shield
4	CAN2_LO	CAN 2 Low
5	CAN2_HI	CAN 2 High
6	CAN1_SHLD	CAN 1 shield
7	CAN1_LO	CAN 1 Low
8	CAN1_HI	CAN 1 High
9	GND	Ground
10	+VBATT	Power
11	INPUT3_D	Digital input
12	INPUT4_D	Digital input
13	INPUT5_D	Digital input
14	INPUT6_D	Digital input
15	GND	Ground
16	INPUT21_A	Analog input
17	INPUT22_A	Analog input
18	INPUT25_F	Frequency input
19	OUTPUT1_HS	High-side output
20	OUTPUT4_0A7_LS	0.7A Low-side output

Table 12: Black (J2) Connector Pin-out

Connector pin	Name	Function
1	INPUT17_D	Digital input
2	INPUT16_D	Digital input
3	INPUT15_D	Digital input
4	INPUT14_D	Digital input
5	INPUT13_D	Digital input
6	INPUT12_D	Digital input
7	INPUT11_D	Digital input
8	INPUT10_D	Digital input

Connector pin	Name	Function
9	INPUT9_D	Digital input
10	INPUT8_D	Digital input
11	INPUT23_A	Analog input
12	INPUT24_A	Analog input
13	INPUT26_F	Frequency input
14	OUTPUT3_2A5_LS	2.5A Low-side output
15	OUTPUT2_HS/INPUT27_A	High-side output/Analog input
16	INPUT18_D	Digital input
17	INPUT19_D	Digital input
18	INPUT20_D	Digital input
19	INPUT7_D	Digital input
20	SENSOR_SUPPLY	+5V sensor power

Table 13: Black (J4) USB Connector Pin-out

Connector pin	Name	Function
1	USB_D-	USB data low
2	USB_VCC	USB power (5V from Host)
3	USB_D+	USB data high
4	USB_GND	USB ground (0V from Host)

15. Installing a DPS into a Vehicle

Because every system is different, it is difficult for us to provide specific instructions on how to install a DPS into a vehicle. Instead, we have provided **mechanical, environmental, and electrical guidelines and requirements** that you should be aware of before installing the product.

INFORMATION

The vehicle manufacturer is responsible for creating procedures for mounting the DPS in a vehicle during production assembly.

15.1. DPS Mechanical Requirements

Review the following mechanical requirements before selecting a mounting location for the DPS:

- The DPS should be mounted with the panel oriented as close to perpendicular to the operator's viewing angle as possible.
- The harness should be **shielded from harsh impact**.
- The harness should **connect easily** to the connector and have **adequate bend radius**.
- The should be easy to read.
- The DPS should be in a location that is **easily accessible for service**.

15.1.1. Mounting the DPS to a Vehicle

It is up to the original equipment manufacturer (OEM) to ensure the product is securely mounted to the vehicle.

The following guidelines are related to physically attaching the DPS to a vehicle:

- The DPS should be secured with **screws in all 7 screw holes** using #10-32 screws.
- The screws should be tightened according to the .
- A trim ring is recommended (to be supplied by the OEM).

15.1.2. DPS Dimensions

The following shows the dimensions of the DPS in millimeters [inches]:

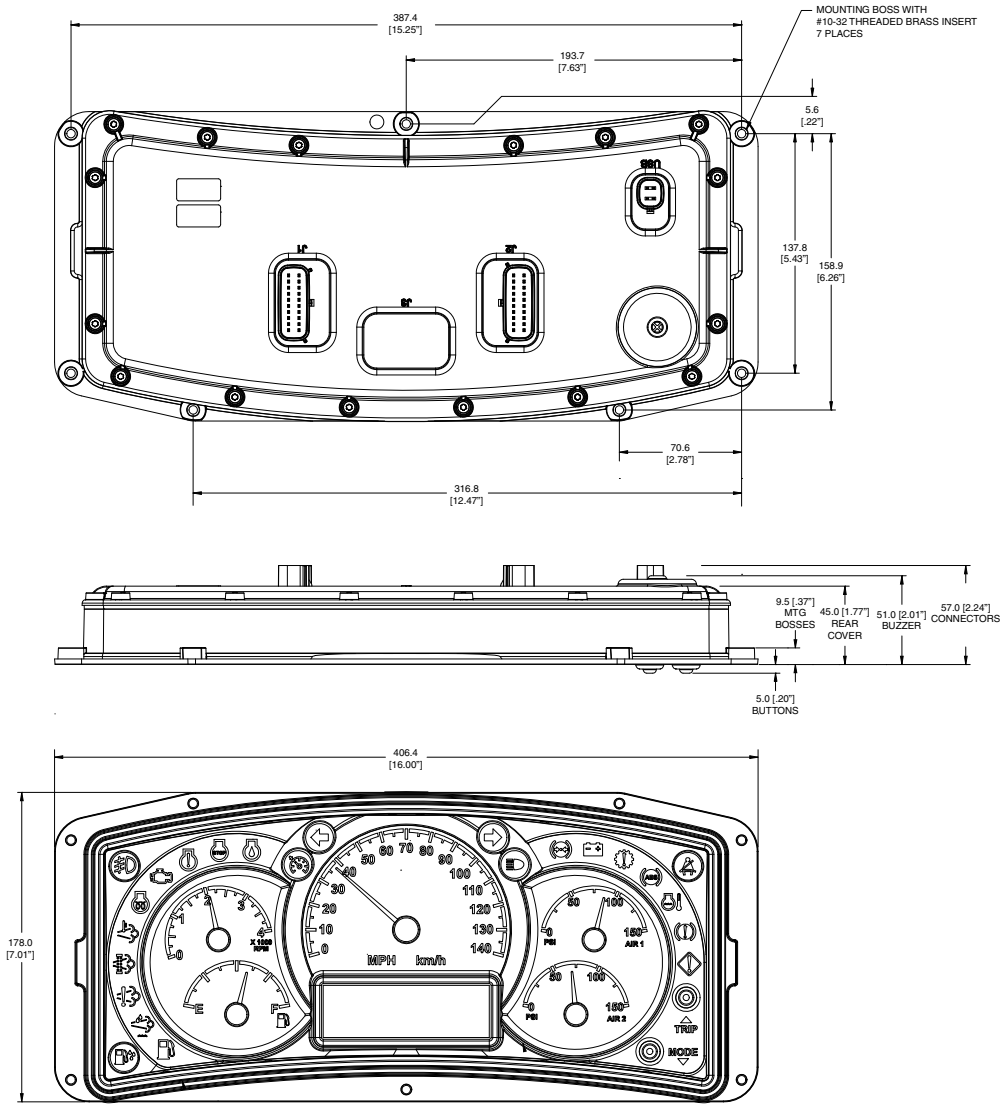


Figure 14: DPS dimensions

15.2. DPS Environmental Requirements

The DPS is intended to be mounted in a panel or dashboard in a vehicle. Typically this is in an enclosed cab or operator station.

NOTICE

The DPS warranty does not cover damage to the product when exposed to environmental conditions that exceed the design limitations of the product.

Review the following environmental specifications before selecting a mounting location for the DPS:

- The DPS must be in an environment that is within its ambient temperature range.
  - Safe operating temperature range for a DPS is **–40°C to +85°C**.
- The DPS must be in an environment that does not exceed its ingress rating.
  - The sealing standard for the DPS is **EP455 level 1 (IPX6)** from the front.

15.3. DPS Electrical Requirements

The DPS is powered with a direct battery connection (+VBATT) on connector pin J1-10, and a ground connection on connector pins J1-9, and J1-15. The direct battery connection does not cause the cluster to power up in normal operating mode by itself. All functions are switched on and off with power up sources (wake-up digital inputs, buttons). The direct battery input is protected against vehicle transients such as load dump, inductive load switching, etc. It is also protected against reverse battery voltage of -42V by creating a high current path that will cause the external fuse (required) to blow.

The following table provides the electrical requirements of the DPS:

Table 14: DPS Electrical Specifications

ITEM	Min	Nom	Max	Units
Input voltage for normal operation when configured for both 12V and 24V system	8	12	32	Volts
Minimum voltage during cranking	5.5			Volts
Over Voltage Protection (DC)			42	Volts
Over Voltage Shutdown Voltage	33	34		Volts
Reverse Battery Protection			-42	Volts
Maximum Continuous Current			12.6	Amps
Off-State Current when configured for either 12V system only or 24V system only			1	mA

ITEM	Min	Nom	Max	Units
Off-State Current when configured for 12V and 24V system			2	mA
Maximum Current Rating of External Fuse			20	Amps

16. Startup

16.1. Start-up procedures

This chapter contains instructions for action to be taken in connection with the initial start.

WARNING

Risk of injury!
If the control system is not fitted properly, the machine could move uncontrollably. The machine's engine shall not be started before the control system is completely fitted and its signals are verified.

16.1.1. Starting the control system

Start the control system as follows:

- Prior to start, all modules and cables are to be fitted correctly.
- Check fuses, i.e. make sure that the supply voltage to the modules is equipped with the correct fuse.
- Make sure that connections for supply voltage and return lines are correct in the cable's conductor joint.
- Make sure the emergency stop works.
  - The emergency stop should disconnect the supply voltage to all modules.

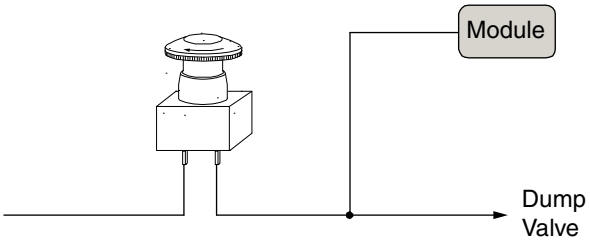


Figure 15: Emergency stop

Alternatively, the emergency stop may also shut off the diesel engine or a dump valve, and with that depressurize the hydraulic system.

16.1.2. Prepare for system start

WARNING

Make sure no one is in dangerous proximity to the vehicle to avoid injuries when it starts.

Prepare for the initial system start as follows:

- The engine for the hydraulic system's pump shall be in off position.
- Make sure that all connectors are properly connected.
- Turn on the control system.
- Make sure that voltage is being supplied to all modules.
- Make sure the emergency stop is functioning properly.

16.1.3. Start the system

Start the system as follows:

- Start the engine for the hydraulic system's pump, assuming that the above mentioned inspections have been carried out and shown correct values.
- Calibrate and adjust input and output signals, and check every output function carefully.
- In addition to these measures, the machine shall also meet the machine directives for the country in question.

17. Appendix A

17.1. DPS Technical Overview

The following table lists the results for verification tests that were performed for the DPS:

Table 15: DPS Technical Specifications

Test	Test Specification	Notes
High Temperature Soak	Vansco Spec 5.1.1	96h soak at +85°C
Low Temperature Soak	Vansco Spec 5.1.2	96h soak at -40°C
Temperature Cycle	EP455 (Feb 2003) Section 5.1.1 – Level 2	
Temperature Shock	J1455 (Jun 2006) Section 4.1.3.2	
Handling Shock	J1455 (Jun 2006) Section 4.11.3.1	
Installation Shock	EP455 (Feb 2003) Section 5.14.2.1	
Operational Shock	EP455 (Feb 2003) Section 5.14.1	
Random Vibration	J1455 (Jun 2006) Section 4.10.4.2	
Particle Impact (Lenses/Display Glass)	Vansco Spec 5.2.7	Drop a 50g steel sphere onto the display lens
Altitude (Storage)	EP455 (Feb 2003) Section 5.2.2	
Dust Ingress	IEC 60529 (Feb 2001) Sections 13.4 and 13.5 – IP5X Rating	
Water Ingress	IEC 60529 (Feb 2001) Section 14.2.6 – IPX6 Rating from the front	
Humidity Soak	EP455 (Feb 2003) Section 5.13.2	
Humidity and Temperature Cycle	EP455 (Feb 2003) Section 5.13.1	
Salt Spray	IEC 68-2-11 Part 2 (1981)	
Readability	EP455 (Feb 2003) Section 5.4.2 – Level 2	
Solar Radiation, UV Effects	IEC 68-2-5:1975 Part: Test S Procedure C	
Chemical Exposure	J1455 (Jun 2006) Section 4.4 EP455 (Feb 2003) Section 5.8.2	
Electrical Steady State (Operating Voltages)	EP455 (Feb 2003) Section 5.10.1	

Test	Test Specification	Notes
Electrical Steady State (Over-Voltage)	EP455 (Feb 2003) Section 5.10.2 – Level 2	
Electrical Steady State (Reverse Polarity)	EP455 9Feb 2003) Section 5.10.3	
Electrical Steady State (Short Circuit)	EP455 (Feb 2003) Section 5.10.4	
Electrical Steady State (Power Up Operational Requirements)	EP455 (Feb 2003) Section 5.10.7	
Electrical Transients (Inductive Load Switching – Power Lines)	ISO 7637-2 (Jun 1990) Section 4.6.1 J1113/11 (Jan 2006)	
Electrical Transients (Alternator Field Decay)	EP455 (Feb 2003) Section 5.11.2	
Electrical Transients (DC Motor Field Decay)	ISO 7637-2 (Jun 1990) Section 4.6.2	
Electrical Transients (Mutual Coupling – Power Lines)	ISO 7637-2 (Jun 1990) Section 4.6.3 J1113/11 (Jan 2006)	
Electrical Transients (Mutual Coupling – Signal Lines)	ISO 7637-3 (Jul 1995) Section 4.5 J1113/11 (Jan 2006)	
Electrical Transients (Cranking)	ISO 7637-2 (Jun 1990) Section 4.6.4 J1113/11 (Jan 2006)	
Electrical Transients (Load Dump)	ISO 7637-2 (Jun 1990) Section 4.6.5 J1113/11 (Jan 2006)	
Accessory Noise	EP455 (Feb 2003) Section 5.11.1	
Batteryless Operation	EP455 (Feb 2003) Section 5.11.3	
Electrostatic Discharge - Surface	EP455 (Feb 2003) Section 5.12	
Electrostatic Discharge - Connectors	ISO 10605 2001(E) Section 5 test level 4	
Electromagnetic Compatibility (Susceptibility) – Safety Critical Applications	ISO 11452 Part 2 (Dec 1995) J1113/21 (Oct 2006)	100 V/m
Electromagnetic Compatibility (Susceptibility) – Non-Safety Critical Applications	ISO 11452 Part 2 (Dec 1995) J1113/21 (Oct 2006)	50 V/m

Test	Test Specification	Notes
Electromagnetic Compatibility (Emissions)	ISO 14982 (Jul 1998) Section 6.4 and 6.5 J1113-41 (May 2000) Level 3	

18. Glossary of Terms

active-high

Input type that is considered "on" when it reads a battery voltage level and "off" when it is floating or grounded.

active-low

Input type that is considered "on" when it reads a ground voltage level and "off" when it is floating or connected to battery voltage.

analog input

An input that allows a voltage level to be read and converted to discrete digital values within a microprocessor.

application software

A level of software that makes a product (hardware) perform desired functions for the end user.

CAN

Controller Area Network

CAN High

One of the wires used in the shielded twisted-pair cable, which provides the positive signal that, when connected with CAN Low, provides a complete CAN differential signal.

CAN Low

One of the wires used in the shielded twisted-pair cable, which provides the negative signal that, when connected with CAN High, provides a complete CAN differential signal.

CAN Shield

A shielding that wraps around the CAN High and CAN Low wires (twisted-pair), completing the shielded twisted-pair cable.

configured

When the hardware configuration of the DPS is changed.

Controller Area Network

A computer network protocol designed for the heavy equipment and automotive environment that allows microcontrollers and other devices to communicate with each other without using a host computer; also known as CAN.

current feedback

A circuit that allows software to measure the amount of current provided by the outputs. This circuit is typically connected to an analog input that is connected to the microprocessor. Note that current feedback is also known as current sense or current sensing.

current sensing

When an analog input reads the amount of current flowing through an output driver circuit.

DC-coupled

A circuit used with signals that have minimal DC offset. The signal being read by this circuit must fall within the detection threshold range specified for the input.

digital input

An input that is typically controlled by an external switch that makes the input either active (on), or inactive (off).

dimension

Selecting value(s) to generate optimal results.

frequency input

An input that allows a frequency value to be read from an oscillating input signal.

gain

Increasing the voltage level of an input signal to maximize the resolution of an input.

ground shift

The difference in ground potential from one harness location to another, which is typical in systems with large wire harnesses and high current loads.

high-side output

An output that provides switched battery voltage to an external load.

inductive load

A load that produces a magnetic field when energized. Inductors are electrical components that store energy and are characterized by the following equation:

$$E_{\text{stored}} = \frac{1}{2}LI^2$$

load

Any component that draws current from the module, and is typically switched “on” and “off” with outputs. Examples include bulbs, solenoids, motors, etc.

low-side output

An output that provides a switched ground voltage to an external load.

open load

A fault state that occurs when a load that should be connected to an output becomes disconnected, which typically occurs because of a broken/worn wire in the wire harness or a broken/worn connector pin.

over-current

A fault state that occurs when a load draws more current than specified for an output, which results in the output shutting down to protect the circuitry of the product.

over-voltage

When the voltage exceeds the normal operating voltage of the product, which results in the DPS shutting down to protect its circuitry.

panel-mounted

The act of mounting a product into a flat panel that has a cutout in the shape of the product.

programmable input

An input that can be programmed in software as digital or analog, with varying voltage ranges and active states.

pull-down

A resistor that connects an input to a ground reference so that an open circuit can be recognized by the microprocessor, which is typically used on active-high digital inputs or analog inputs.

pull-up

A resistor that connects an input to a voltage reference so that an open circuit can be recognized by the microprocessor, which is typically used on active-low digital inputs or analog inputs.

pulse counting

The act of counting the number of pulses that occur over a certain period of time on a frequency input.

Pulse Width Modulation (PWM)

A type of square wave frequency signal where the ratio of “on” time vs. “off” time is determined by the duty cycle of the signal. The duty cycle refers to the percent of time the square wave is “on” vs. “off”. PWM signals are typically used to drive varying amounts of current to loads, or to transmit data.

sensor power

A regulated voltage output that provides a set voltage level for analog sensors attached to the product.

switching threshold current

The minimum amount of current required for an input before the telltale appears “on.”

system noise

Electrical interference generated from external devices that affect the behaviour of inputs, outputs and sensors. System noise can be generated from things like the vehicle alternator, engine, transmission, etc.

translucent

The state in which an icon diffuses light so that objects on the other side of the icon are not clearly visible (also known as semi-transparent).

transparent

The state in which you can see through an icon when the telltale is inactive.

wetting current

The amount of current that flows into, or out of, a digital input. The current helps eliminate oxidation on the contacts of digital switches and relays. Switches with gold or silver contacts typically require much less wetting current than standard tinned contacts.

19. Index

A
active-high • 49
active-low • 49
analog input • 49
Analog Input Capabilities • 15
Analog Input Installation Connections • 16
Appendix A • 46
application software • 49

B
Backlight • 30
Buttons • 35
Buzzer • 36

C
CAN • 49
CAN High • 49
CAN Low • 49
CAN Shield • 49
Communication • 28
configured • 49
Controller Area Network • 49
Controller Area Network (CAN) • 28
current feedback • 50
current sensing • 50

D
DC-coupled • 50
Diagram Conventions • 10
digital input • 50
Digital Input Installation Connections • 14
dimension • 50
Direct Coupled Frequency Input Installation Connections • 18
DPS Analog Inputs • 15
DPS Connector Pin-outs • 38
DPS Connectors • 37
DPS Digital Input Capabilities • 12
DPS Digital Inputs • 12
DPS Dimensions • 41
DPS Direct Coupled Frequency Input Capabilities • 18
DPS Direct Coupled Frequency Inputs • 17
DPS Electrical Requirements • 42
DPS Environmental Requirements • 42
DPS High-Side Output Capabilities • 20
DPS High-Side Output Installation Connections • 21
DPS High-Side Outputs • 20
DPS Low-Side Outputs with Current Sense • 22
DPS Low-Side Outputs with Current Sense Capabilities • 22
DPS Low-Side Outputs with Current Sense Installation Connections • 24
DPS Mechanical Requirements • 40
DPS Outputs • 20
DPS Sensor Power Capabilities • 27

F
frequency input • 50

G
gain • 50
Gauge Backlighting • 33
Gauges • 32
ground shift • 50

H
high-side output • 50
High-Side Output Diagnostics and Fault Protection • 21
How to Use this Manual • 10

I
inductive load • 50
Inputs • 12
Installing a DPS into a Vehicle • 40
Introduction • 5

L
Large Graphic LCD • 31
LCD • 30
LCD Heater • 30
load • 50
Logic and Output Power • 26
Logic and Output Power Installation Connections • 26
low-side output • 50

M
Mounting the DPS to a Vehicle • 40

O
open load • 51
over-current • 51
over-voltage • 51

P
panel-mounted • 51
Power • 26
Precautions • 6
programmable input • 51
pull-down • 51
pull-up • 51
pulse counting • 51
Pulse Width Modulation (PWM) • 51

S
sensor power • 51
Sensor Power • 26
Sensor Power Installation Connections • 27
Startup • 44
Status LEDs • 34
switching threshold current • 51
system noise • 52

T

translucent • 52
transparent • 52

U

Understanding the DPS • 8
USB Communication • 28

W

Wake-up Feature • 35
wetting current • 52